
State of Tennessee
THE GREAT SEAL OF THE STATE OF TENNESSEE
XVI
AGRICULTURE
COMMERCE
1796

State of Tennessee
DRAFT Research
regarding
Multi-year Strategy for Improving Performance of Projects and Project Teams

presented by

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Office of the State Architect (OSA)

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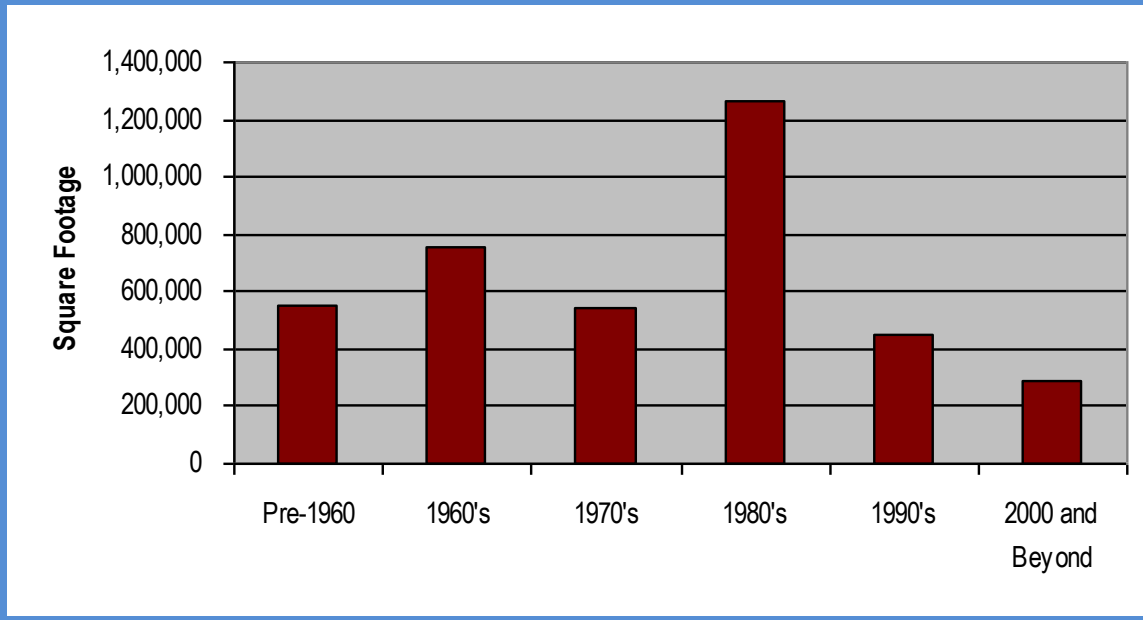
Current FRF Buildings

- Average Age of Owned Portfolio is 35 years
- However, the oldest 43% of the portfolio has an average age of 50 years
- Architecture and technology have surpassed current portfolio



Chattanooga State Office Building
Built 1955

Donnelley J. Hill
Built 1968

Lowell Thomas State Office Building
Built 1977

Citizen's Plaza
Built 1986

Davy Crockett
Built 1989

FY 11/12 FRF (General Government General Office Buildings) Spend Analysis

	Above Industry Standards
Utilities costs	30+%
Repairs and Maintenance costs	63+%

Envision the State's portfolio if one day:

- The majority of projects were designed, built or renovated with the intention of actually lasting 100 years
- When compared to similar projects ten years earlier
    - Cost very little or no more initially to construct or renovate
    - Were highly energy efficient to operate - utilizing 30-50+% less energy on average
    - Were able to be well maintained at significantly lower maintenance costs at rates equal to current industry standards
- The buildings were aesthetically pleasing and functionally designed to
    - add long-lasting cultural value to the area in which they exist and
    - help their inhabitants to be more healthy and productive
    - utilizing current technology, engineering systems, and the best work practices of the day
        - resulting in the occupants being more productive and taking fewer sick days

Three key areas, in priority, to get to this new future destination are:

1. Increasing the State's Use of Collaborative Project Delivery Methods
2. Furthering the State's focus on High Performance Building (HPB) Design
3. Using Building Information Modeling (BIM) on State of Tennessee Projects

Increasing the State's Use of Collaborative Project Delivery Methods

Office of the State Architect

"Traditional" Design-Bid-Build (D-B-B) delivery method continues to be most widely used delivery method, especially by the public sector

- Provides competitive bidding environment
- Provides clear separation of designer and contractor responsibilities and liabilities
- Requires the least effort by Owners on the front-end

However, D-B-B can sometimes

- Create adversarial relationships between the designers and contractors
- Award contracts to low bidders that aren't the most qualified
- Result in numerous Change Orders and RFIs
- Not always be the lowest cost method in the end

While D-B-B will remain the best choice on certain projects, many industry experts now realize other methods may be better suited for certain project types and situations

For instance, when a project is such that some or all of the following conditions exist:

- Scope is not well defined,
- Budget is not well defined,
- Schedule needs to be expedited,
- Complexity level is above average,
- Would benefit from early contractor involvement, and high levels of collaboration between the design and construction team members

It is important to have options as each project has unique characteristics and requirements, so each project team should assess and determine the most appropriate Project Delivery method.

OSA's current policy on Alternative Delivery Methods is based on the State's Quality in Construction (QIC) Task Force 's work product.

- QIC was comprised of members from the design and construction industry and various state agencies which engage in building projects and met in 2004/5 and 2009/10

QIC identified various "alternative" delivery methods beyond D-B-B

- Best Value 1, 2, and 3 (BV1, BV2, BV3) - requires two part contractor submittal. BV1 allows a short listing of contractors based upon qualifications, the award is to the lowest responsible bid. BV2 and BV3 scores both qualifications and bid, allowing best qualified and not necessarily the lowest bid
- Construction Manager/General Contractor (CM/GC) - brings a contractor in early in the design process, providing pre-construction services, to work with the designer and owner to contribute to cost estimating, scheduling, and constructability reviews
- Design-Build (D-B) – provides a single point for responsibility by bringing the designer and contractor in at the same time under one contract

SBC Policy approved the use of these new Alternative Delivery Methods occurred in Dec. 2005

Considering Best Value (BV) as a Good Alternative Delivery Method Option over

Design-Bid-Build (D-B-B)

In general, by utilizing Best Value on projects where Design-Bid-Build may traditionally have been used, the State should benefit from more qualified bidders, and thus reduce its risk via reduced construction rework and associated increases in costs, reduced delays in construction, reduced litigation, reduced number of Requests for Information (RFIs) and associated Change Orders (COs).

Best Value may be the preferred Alternative Delivery Method to D-B-B when the lowest bid is the only criteria for selection, but the Owner wants to be certain the contract is awarded to a qualified bidder, with expertise related to the project's scope of work.

Summary of report - “Influence of Project Delivery on Sustainable, High Performance Buildings”

- November 2010 University of Colorado research project funded by a grant through the Charles Pankow Foundation

To achieve HPB Goals, project complexity increases as does the demand for increased interdisciplinary collaboration including early involvement of participants, higher levels of communication, and compatibility (trust) between project team members

- Project delivery methods often impact the Owner’s ability to achieve higher levels of building performance
- Studies show Design-Bid-Build (D-B-B) strategies may not address the complex demands found in high performance building projects and actually may actually constrain the contractor’s ability to assist in achieving certain high performance building objectives
- Design team separation from the contractor reduces the opportunity for innovative solutions by the contractor and sub-contractors
- Additionally, the (early or late) timing of contractor involvement also is a key factor affecting a building’s performance

It’s difficult to achieve high performance building outcomes without an integrated delivery process

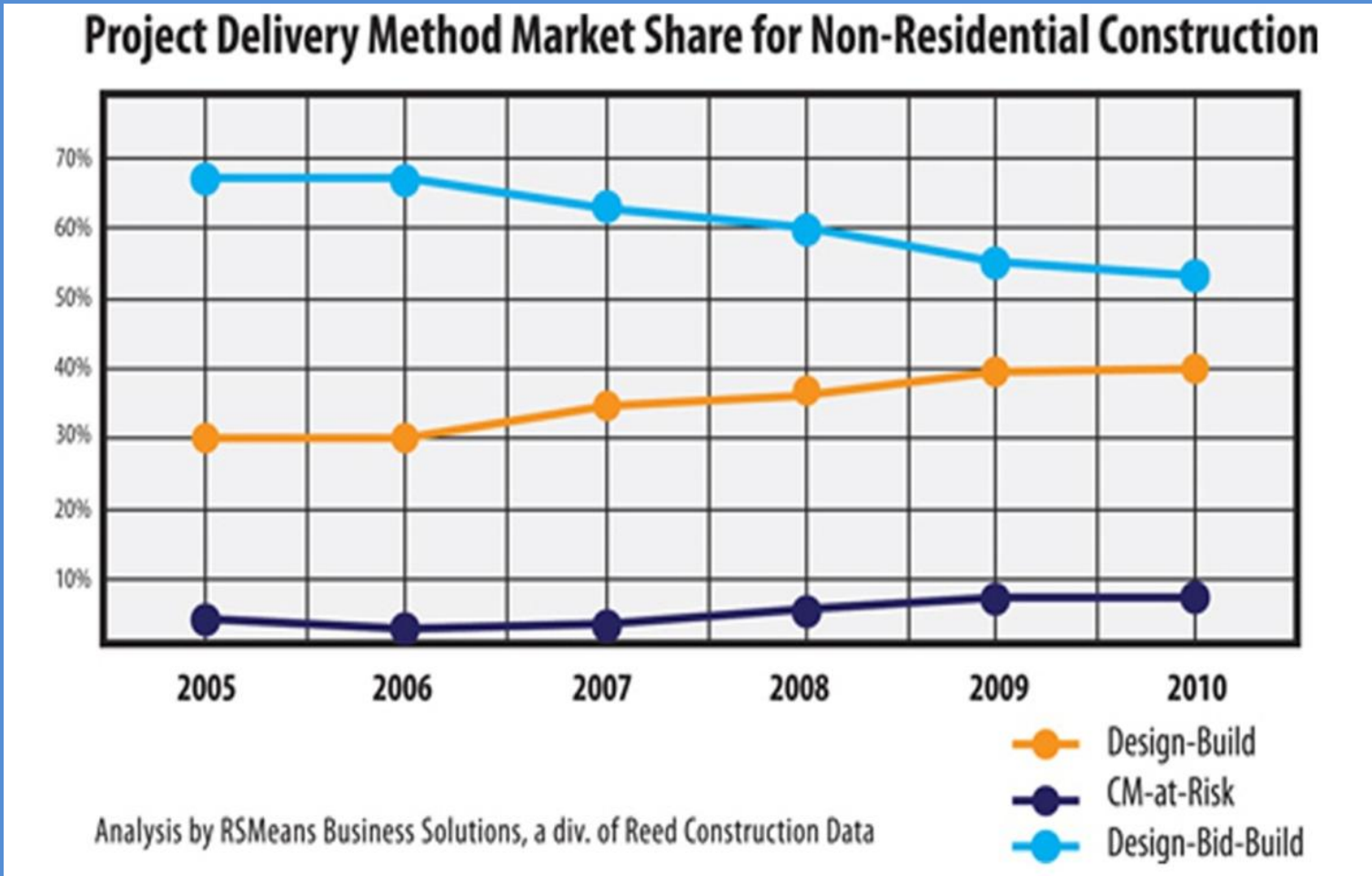
An analysis of Construction Delivery Methods for U.S. Non–residential Vertical Construction

2005

67%
D-B-B

30%
D-B

3%
CM/GC

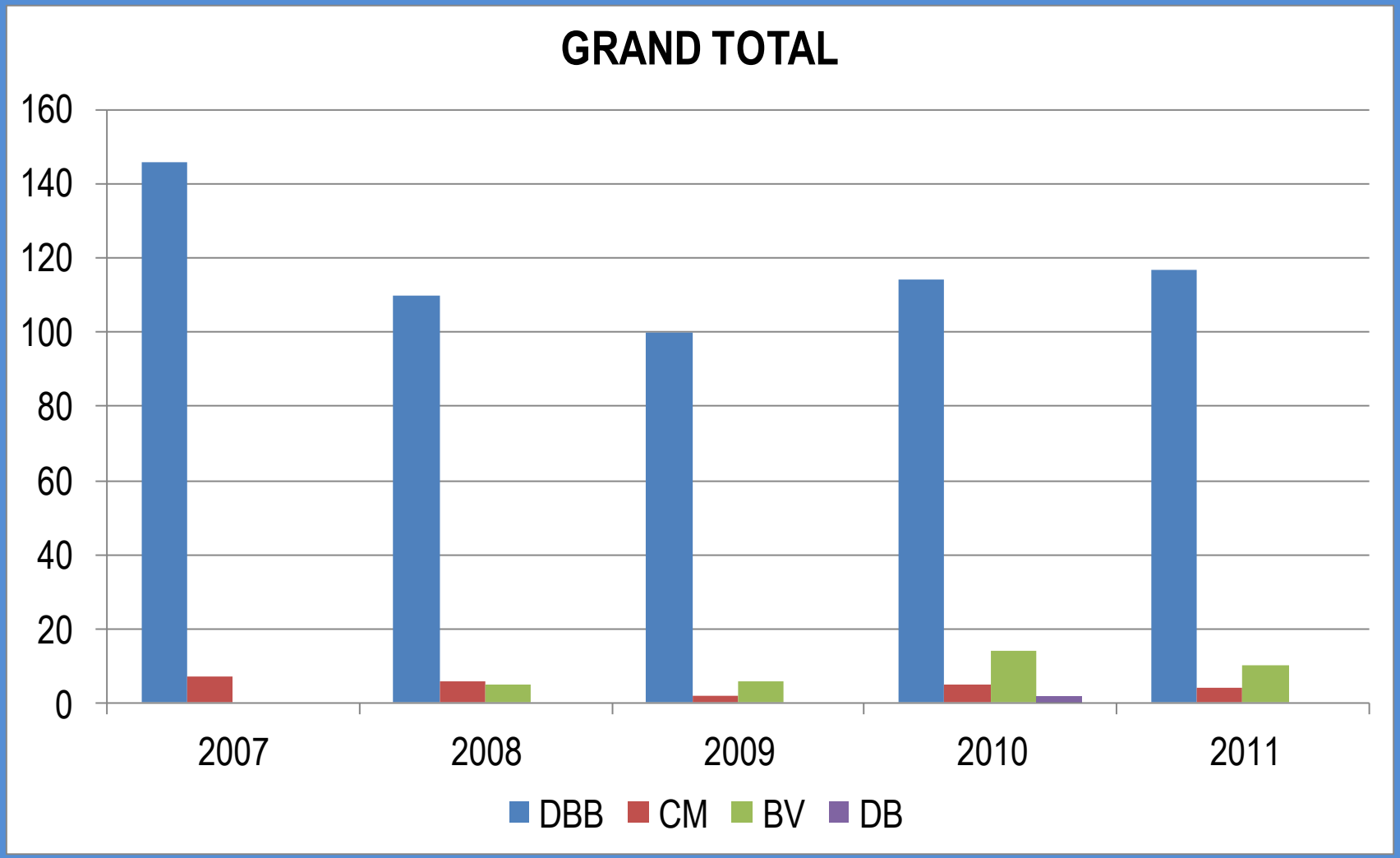


2010

52%
D-B-B

40%
D-B

8%
CM/GC


GRAND TOTAL
160
140
120
100
80
60
40
20
0
2007
2008
2009
2010
2011
DBB
CM
BV
DB

Integrated Project Delivery

The Integrated Project Delivery Guide was jointly developed by AIA's Contract Documents Committee and the AIA California Council.

Integrated Project Delivery is a project delivery process that:

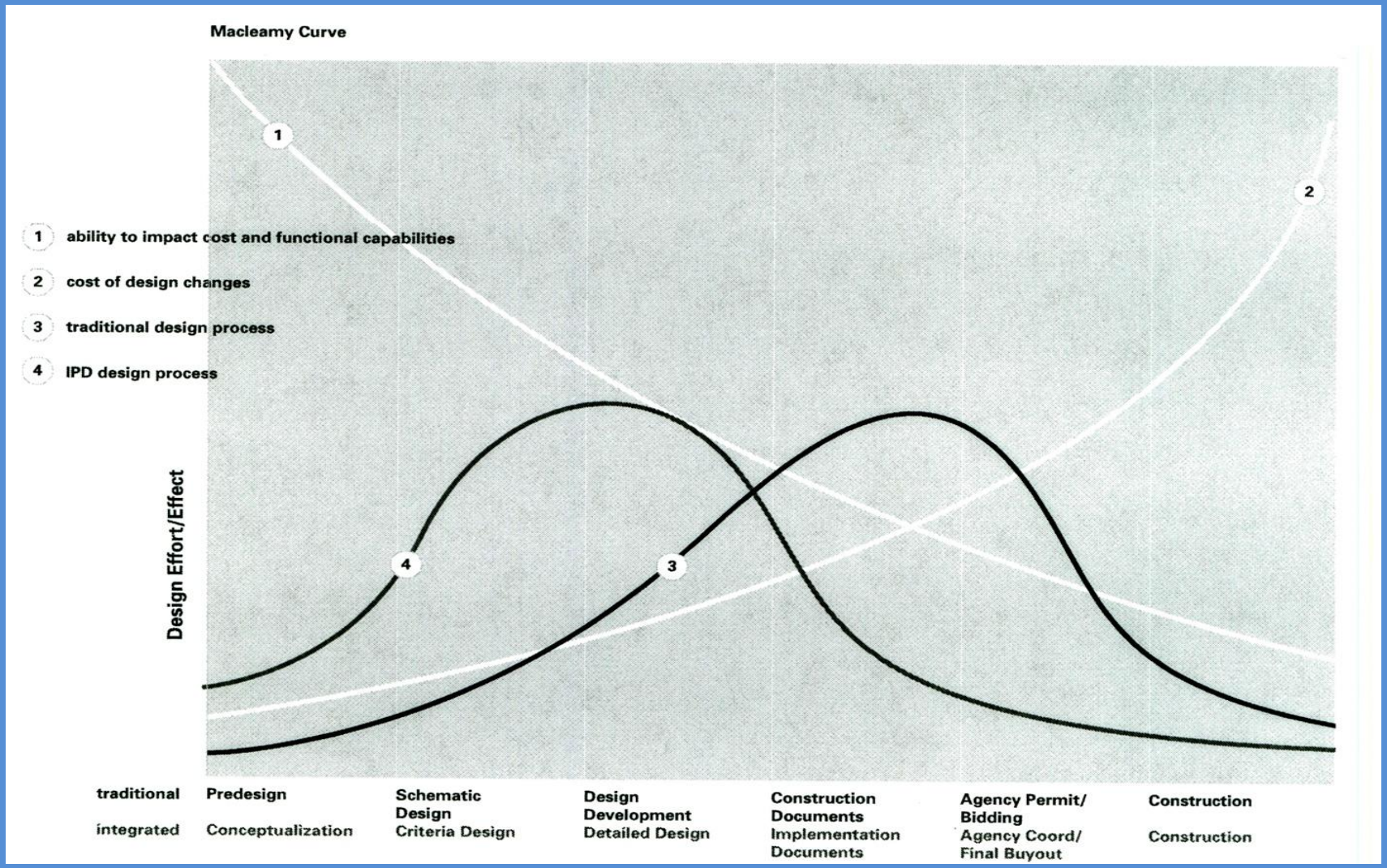
- Collaboratively harnesses the talents and insights of all participants
- Optimizes project results:
  - Increases value to the owner
  - Reduces waste
  - Maximizes efficiency through all phases of design, fabrication and construction

The process is distinguished by:

- Highly effective collaboration among Owner, designers and contractors at a minimum
- Commences at early design
- Continues through to project handover or later

To do so requires the Owner's decision to use an Integrated (Design and Construction) Project Delivery Method

- Leverages early contributions of knowledge and expertise
- Through utilization of new technologies like BIM, the values such highly collaborative delivery methods offer can be further expanded


Macleamy Curve
1 ability to impact cost and functional capabilities
2 cost of design changes
3 traditional design process
4 IPD design process
Design Effort/Effect
1
2
3
4
traditional
integrated
Predesign
Conceptualization
Schematic Design
Criteria Design
Design Development
Detailed Design
Construction Documents
Implementation Documents
Agency Permit/ Bidding
Agency Coord/ Final Buyout
Construction
Construction

Teams are guided by principles of:

- effective (trust-based) collaboration
- transparent processes and sharing of open information
- team success tied to project success and shared risk and reward
- value-based decision making
- utilization of full technological capabilities and support

Effectively structured, trust-based collaboration encourages parties to focus on

project outcomes rather than their individual goals

- Without trust-based collaboration –
    - Participants will remain in the adverse and antagonistic relationships that plague so much of the design and construction industry's productivity today

IPD provides positive value propositions for the three major stakeholder groups:

- ***for Owners***
  - the integrated delivery strengthens the project team's understanding of the owner's desired outcomes
  - improves the team's ability to control costs and manage the budget, which
  - increases the likelihood that project goals –
    - schedule
    - life cycle costs
    - quality

    will be achieved

IPD provides positive value propositions for the three major stakeholder groups:

- ***for Designers***
  - allows the designer to benefit from the early contribution of contractor's expertise during the design phase –
    - accurate budget estimates to inform design decisions
    - pre-construction resolution of design-related issues
    - improved project quality and financial performance

IPD provides positive value propositions for the three major stakeholder groups:

- ***for Contractors***
  - allows them to contribute expertise in construction techniques early in the design process
  - the contractor's participation during the design phase provides –
    - strong pre-construction planning
    - more timely and informed understanding of the design
    - anticipating and resolving design-related issues
    - visualizing construction sequencing prior to construction start
    - improved cost control and budget management
  - results in improved project quality and financial performance during the construction phase

Furthering the State's Focus on High Performance Building (HPB) Design

High Performance Building (HPB) Design

- Requires a holistic approach to design and construction which
  - Considers a building's energy load as a whole
  - Integrates energy-efficient measures in order to
    - Reduce demand
    - Reduce off-site generated energy consumption and
    - Results in a high quality product that maximizes the owner's return on investment and reduces their total cost of ownership (life cycle costing vs first cost)

High Performance Building Design (continued)

- Includes all players in some form of a highly collaborative design and construction process like CM/GC, Design-Build, and Integrated Project Delivery
    - Owner
    - Design team (a/e)
    - Construction team (materials manufacturers, contractors, waste managers)
    - Operating / maintenance staff
- Often utilizes Building Information Modeling (BIM) as a tool to reach a higher level of project and team performance

- Even with possible higher first costs for construction of certain high performance building features, these costs are typically recovered within a reasonable payback period.
- Integrated project delivery methods utilizing a multidisciplinary team approach to problem solving will reduce first and ongoing operating costs
    - Specific project team actions should include:
        - Setting and prioritizing high performance goals in each project's definition, and including those goals in the designer and contractor selection processes
        - Budgeting for any higher first costs
        - Basing decisions on life-cycle cost analyses (LCCA)
        - Using energy modeling to inform the design

- By making the right decisions during design and construction, reductions in operation and maintenance costs can be realized – often with little or not additional up-front costs
  - 2003 State of California commissioned “The Costs and Financial Benefits of Green Buildings” concluded “that minimal increases in upfront costs of about 2 percent would, on average, result in life cycle savings of 20 percent of total construction costs
    - Example - $10,000 up-front investment on a $5 mil project would result in a savings of $1 mil in today’s dollars over the life of the building”

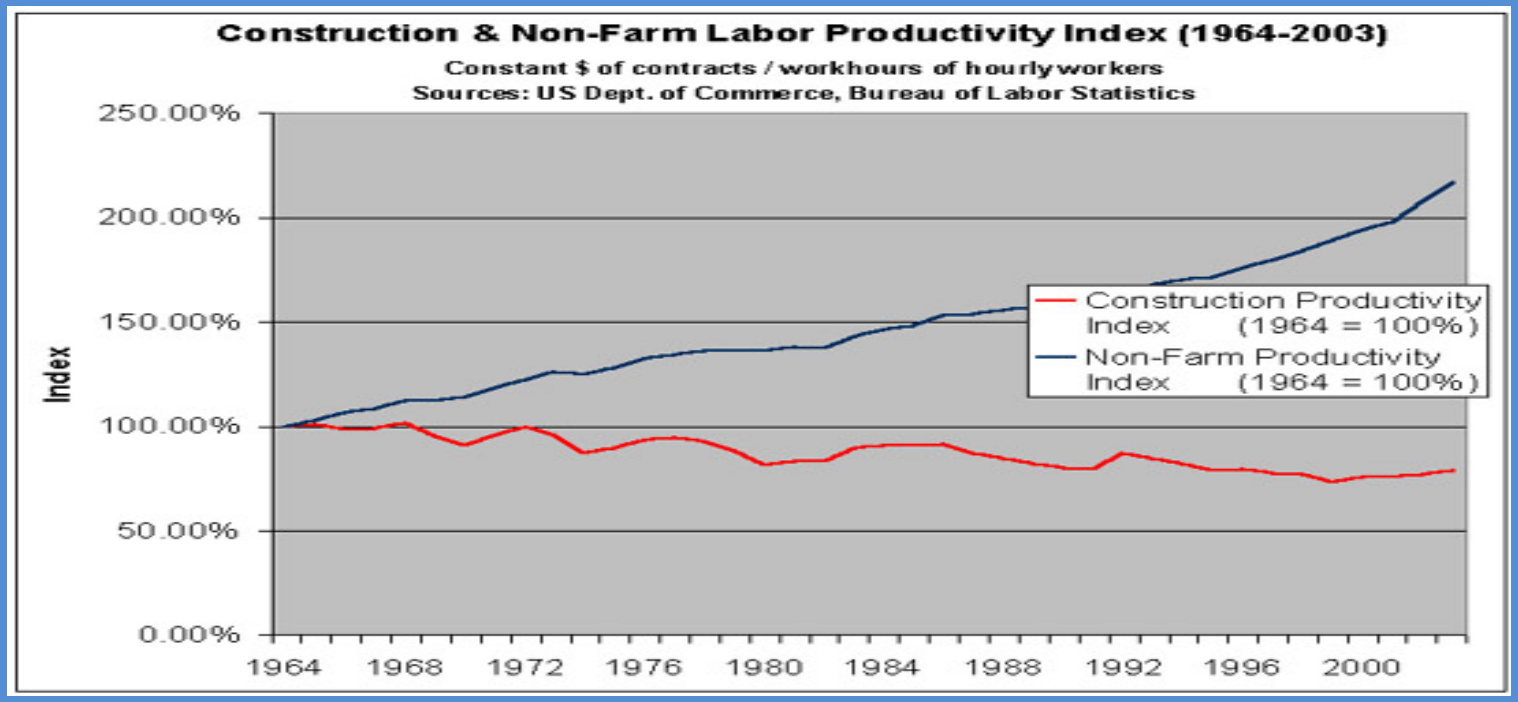
- Federal government's GSA now "requires all new-construction and major modernization projects to be certified through the LEED program, with an emphasis on obtaining Silver ratings."
  - New budget allocations (typically varying between 2.5 and 4.0%) are enough to ensure this can be achieved and project teams are encouraged to achieve the highest level of LEED rating that is practical within the overall budget.
  - This range of estimated construction cost impact for LEED certified, Silver and Gold targeted projects falls below the normal 10+% concept phase estimating accuracy

- Better buildings equate to better employee productivity
  - Better engineering systems, etc. enhance occupant health and well being
  - Healthier buildings and occupants can increase human productivity and reduce liability

Using Building Information Modeling (BIM) on State of Tennessee Projects

Office of the State Architect

The US Department of Commerce, Bureau of Labor Statistics tracking of the construction industry's productivity



+ 115%

- 30%

As measured by dollars of new construction work / field work hour, labor productivity in the construction industry has trended downward over the past 40 years

- Totaling approx – 30% decrease over the past 40 years

In other words, construction projects have required significantly more field work hours per constant dollar of contract.

Additionally, while most other industries are improving their productivity, the construction industry seriously lags other industries in developing labor saving ideas and in finding ways to substitute equipment and technology for labor.

- Despite the fact that there has been a significant adoption of new information technology by the construction industry over the past 35 years, these applications tend to run in a stand-alone mode which does not encourage improved collaboration by other members of the project team.

Much has been published about the four factors that can positively affect construction productivity.

One of these is:

(1) utilization of technology

Other three factors are:

(2) life-cycle design and construction processes

(3) availability of skilled labor and

(4) use of off-site fabrication and modularization

Utilization of technology, and BIM in particular, has been identified as extremely valuable tool to increase productivity of project teams and improve the quality control of built projects by

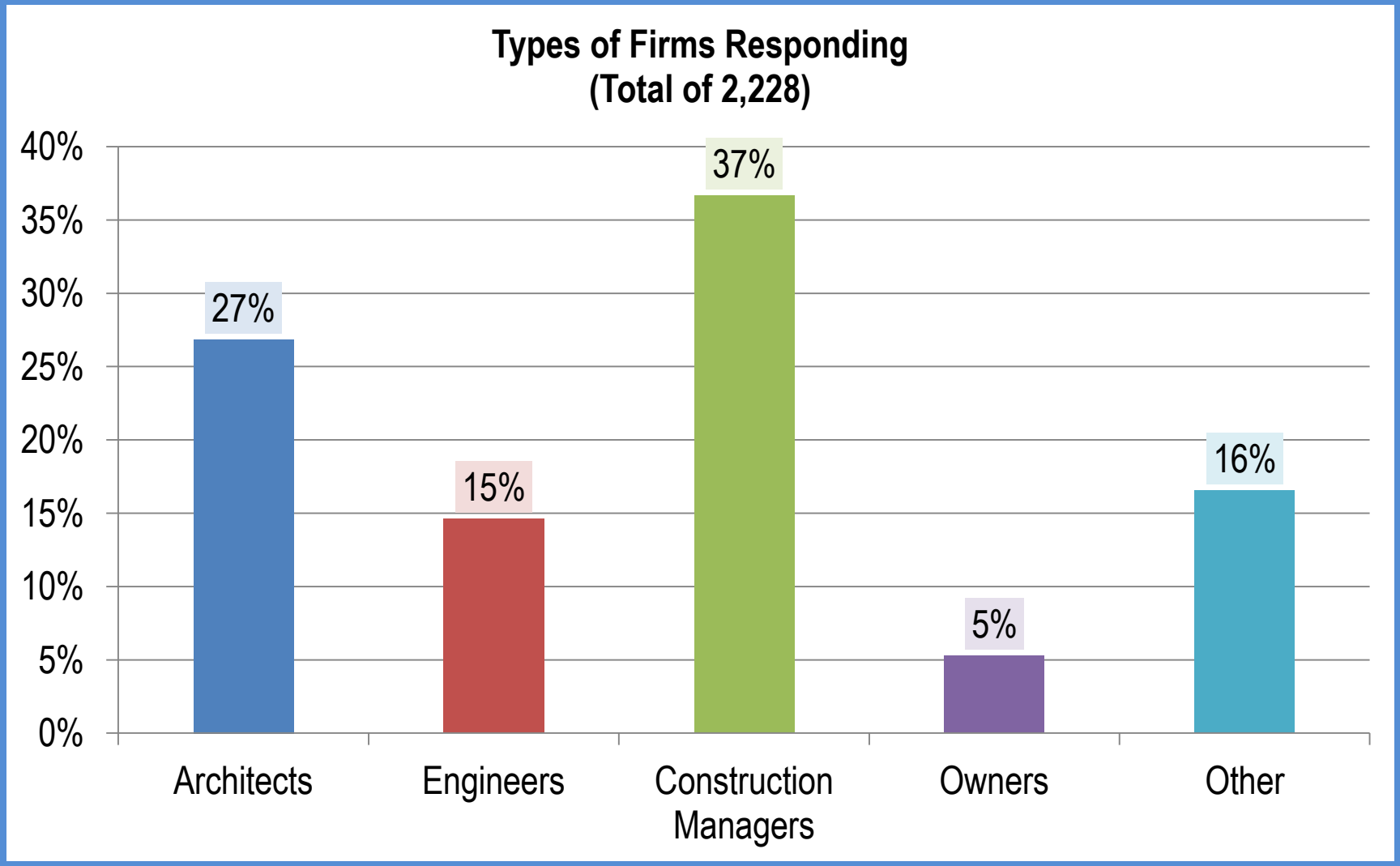
- enabling critical communications and collaboration,
- sharing of information between different parties,
    - to achieve high performance building goals
    - throughout a project's total life cycle of design, construction and operations

Building Information Modeling

- a digital, three-dimensional model
- linked to a database of project information
- one of the most powerful tools supporting IPD
- BIM can combine in one database:
    - the design
    - fabrication information
    - erection instructions
    - project management logistics
- BIM provides a platform for collaboration throughout the project's design and construction

Building Information Modeling

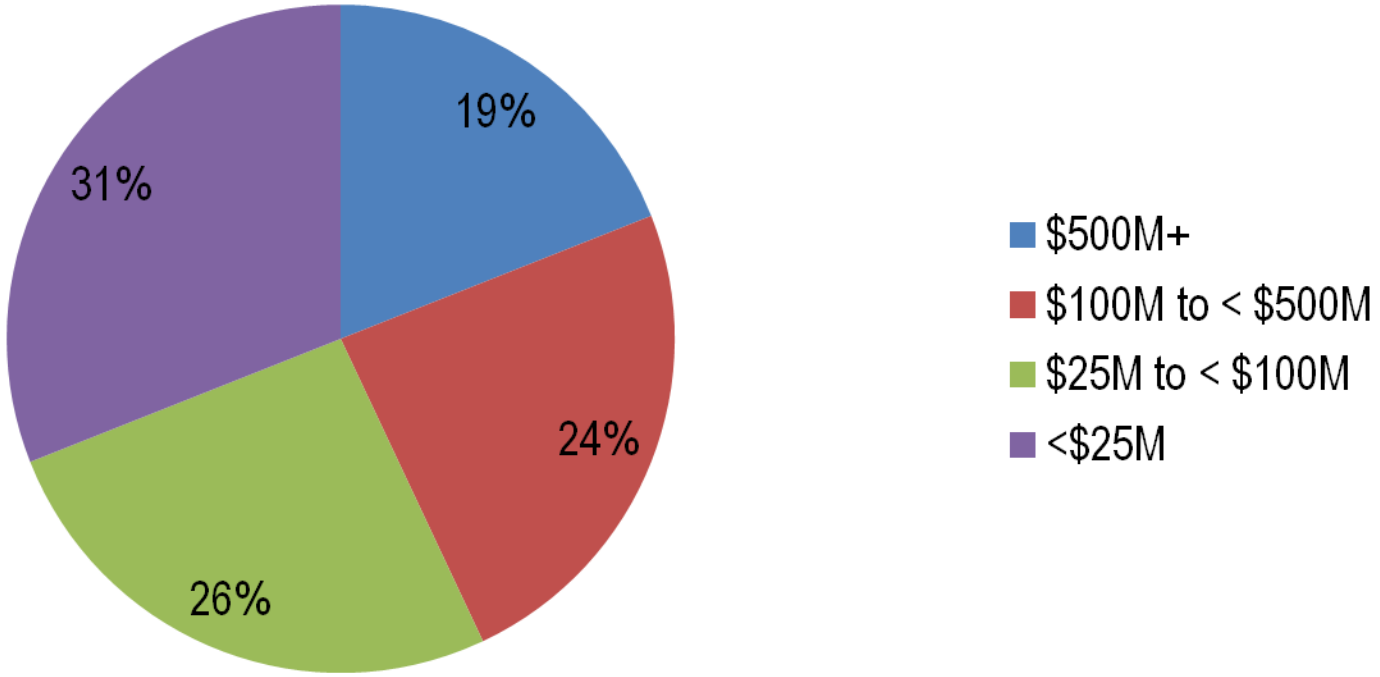
- because the model and more importantly its database can exist and be more easily updated (if properly maintained by the Owner) for the life of a building, the Owner may use BIM
    - to manage the facility well beyond completion of construction
    - for such purposes as –
        - space planning
        - furnishing
        - monitoring long-term energy performance
        - Maintenance
        - Remodeling



McGraw Hill Construction's report "The Business Value of BIM" July 2009

Company Size

CM / General Contractors, Fabricators, Estimators, Owners, Building Product Manufacturers/Distributors



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Company Size by Level of Expertise Using BIM

	Total	Beginner	Moderate	Advanced	Expert
	(Total=1,623)	(Total=164)	(Total=304)	(Total=241)	(Total=117)
Large Company	22%	30%	43%	34%	42%
Medium to Large Company	27%	32%	23%	25%	21%
Small to Medium Company	20%	24%	21%	27%	21%
Small Company	32%	14%	13%	13%	16%

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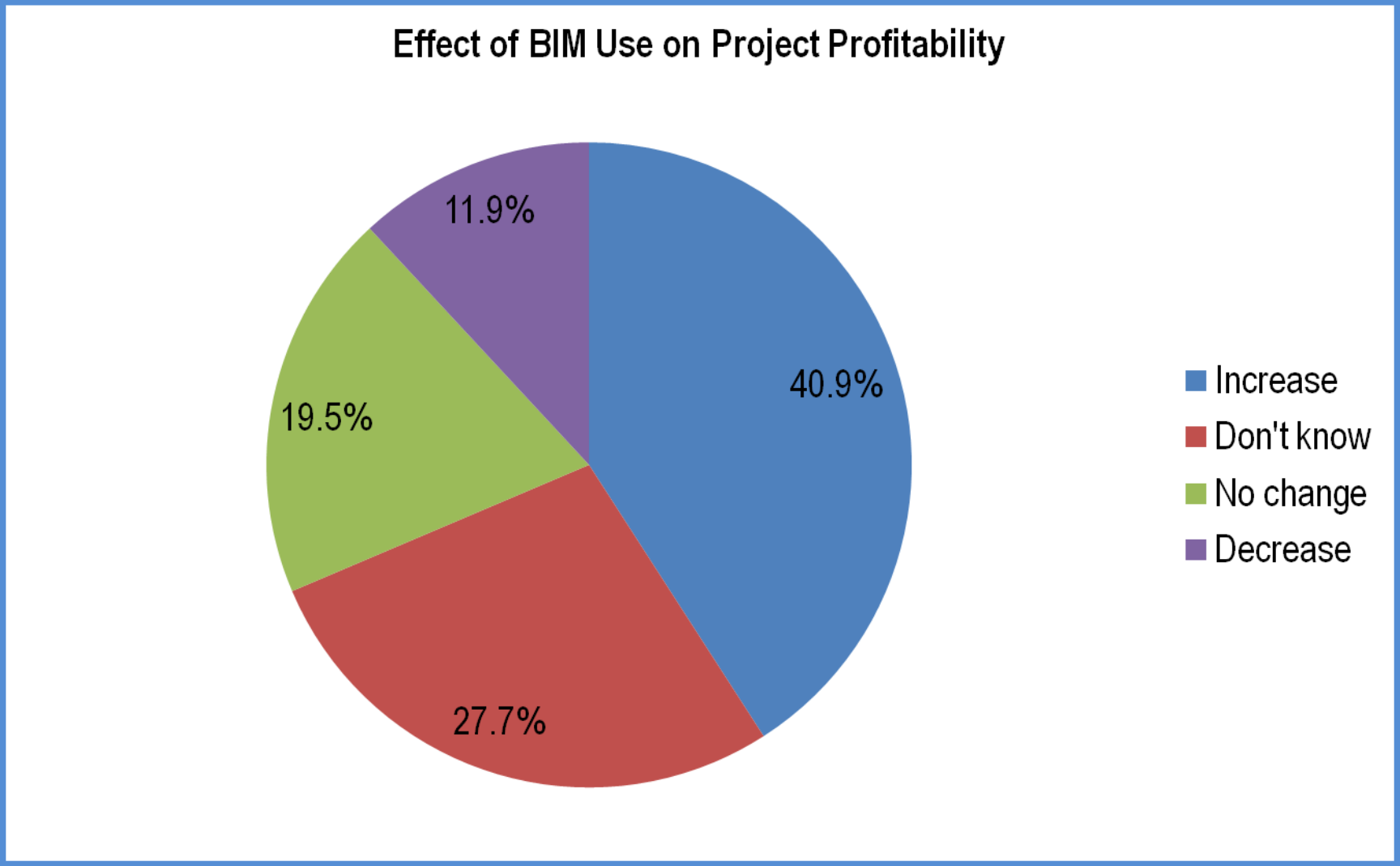

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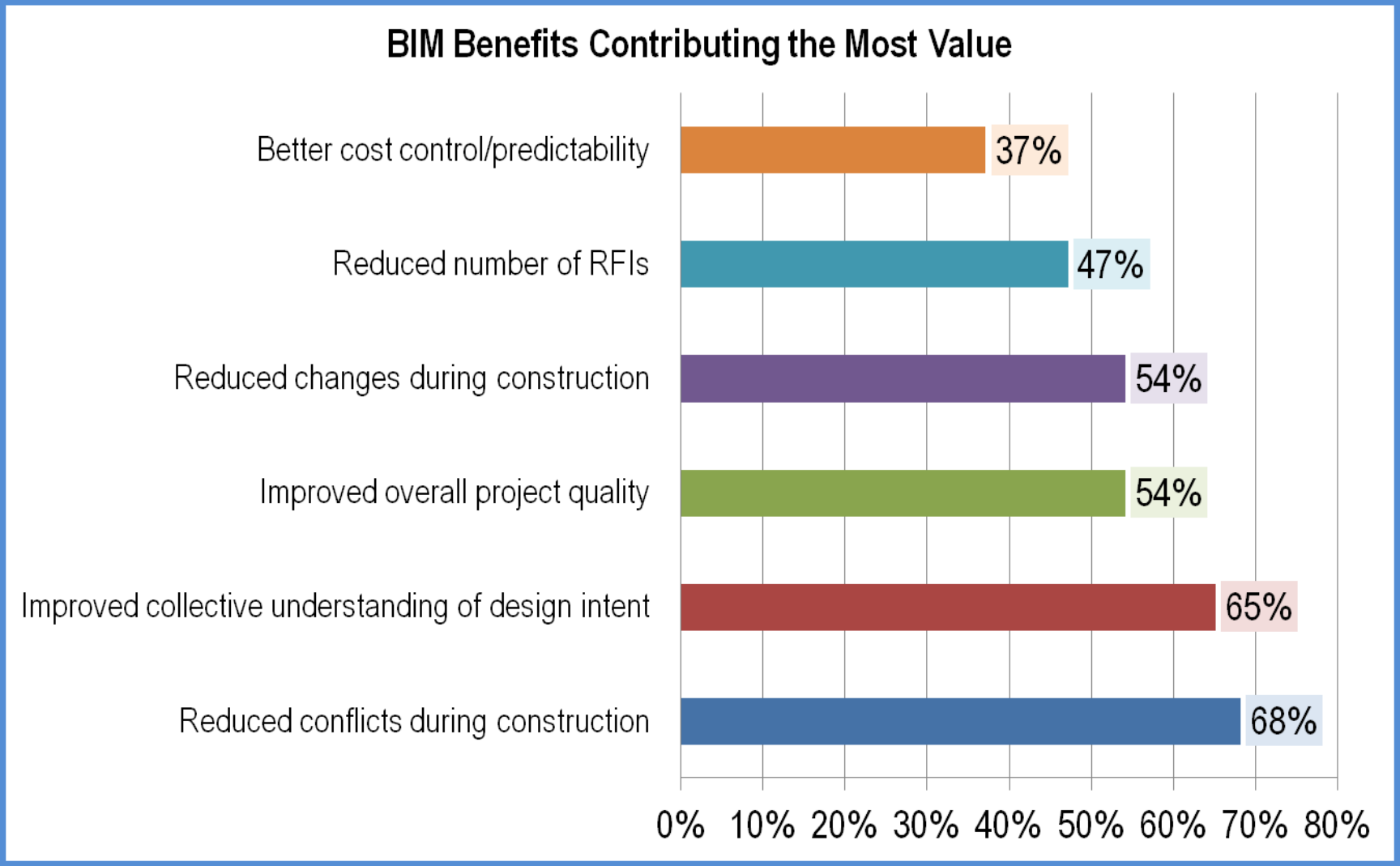


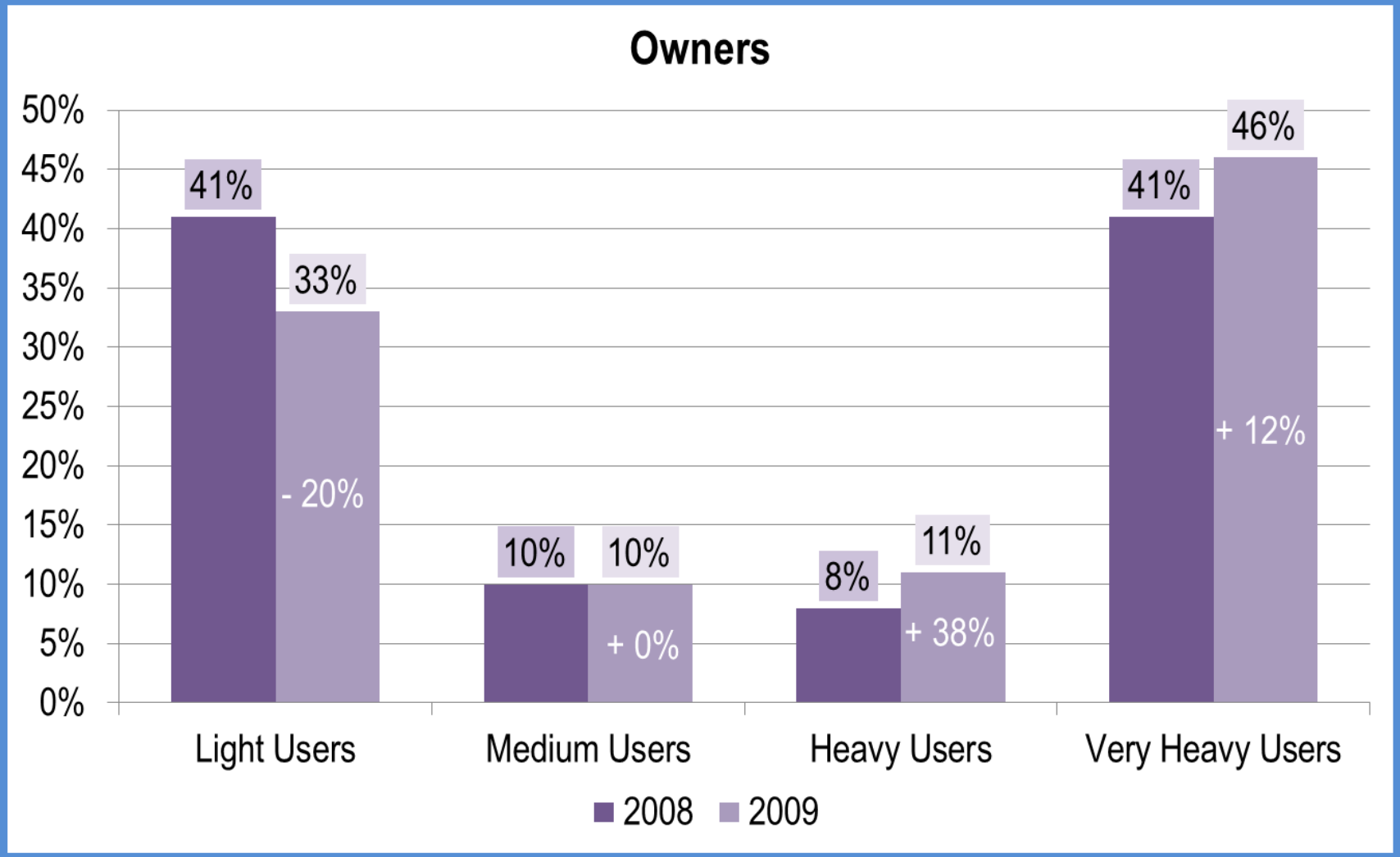
McGraw Hill Construction's report "The Business Value of BIM" July 2009

Regarding AEC industry adoption of BIM

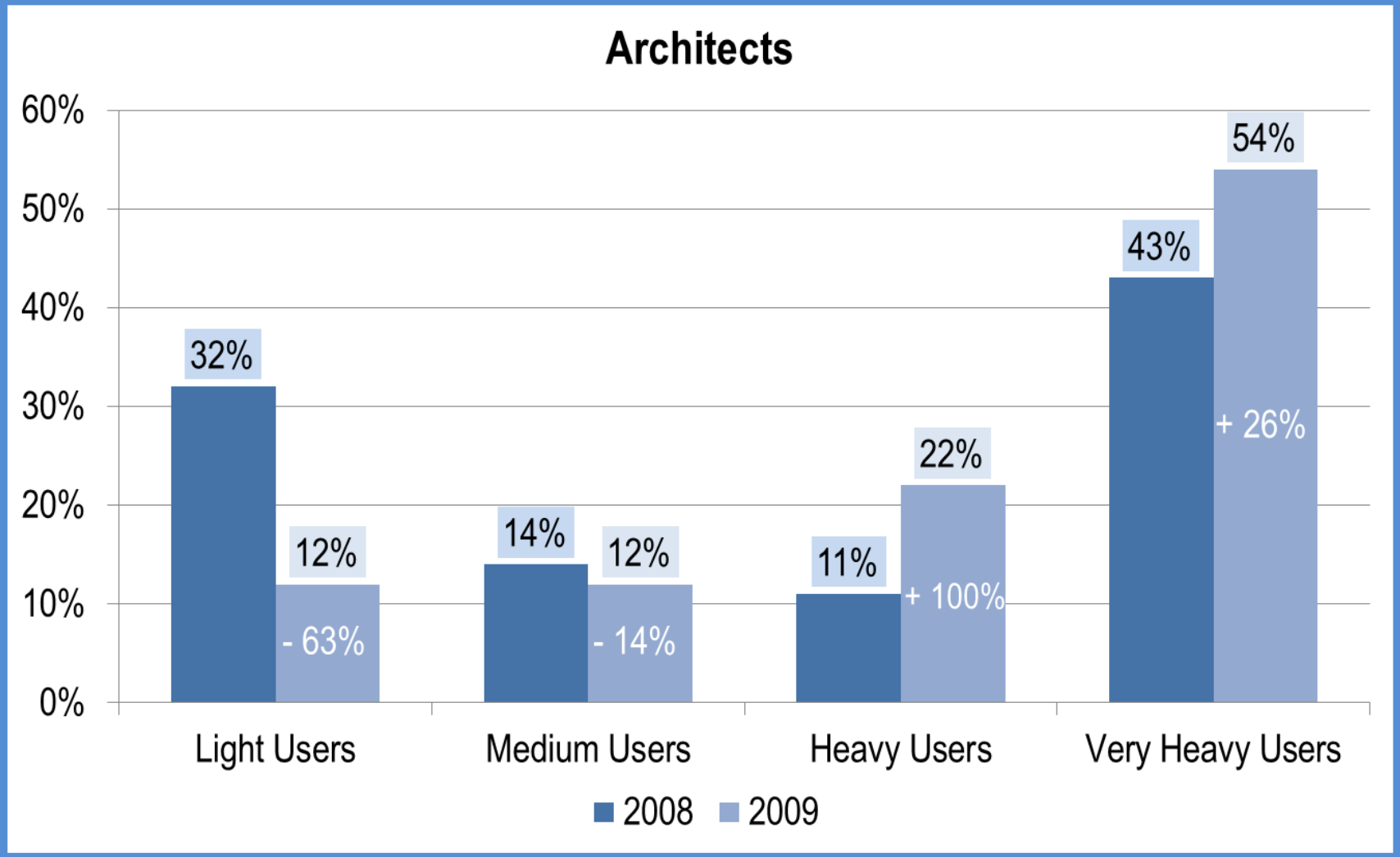
Fastest growing market segments adopting BIM as of 2009

- Public Work 35%
- Health Care 28%
- Education 24%
- Private and other 13%

Growth in BIM Use on Projects



Growth in BIM Use on Projects



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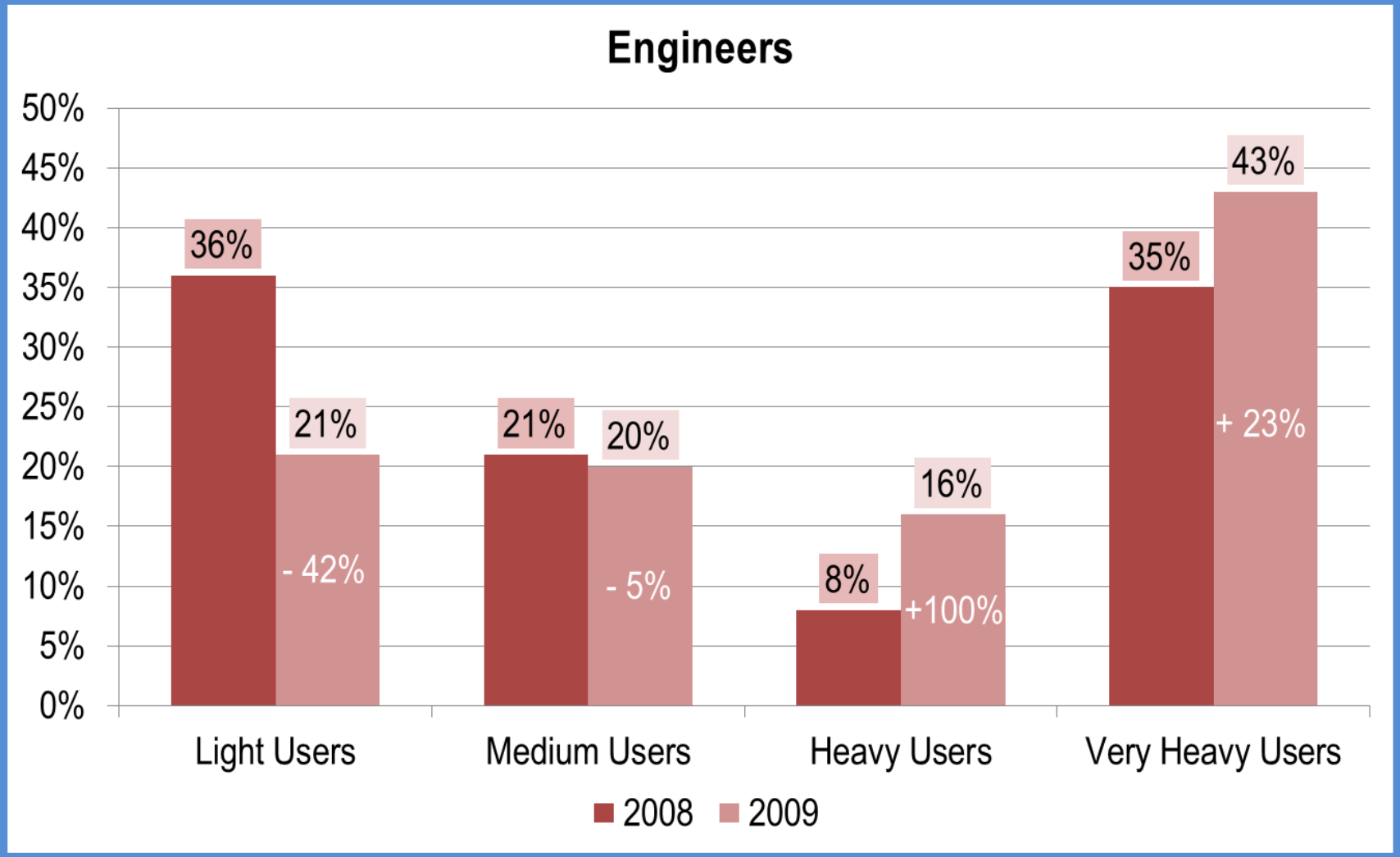

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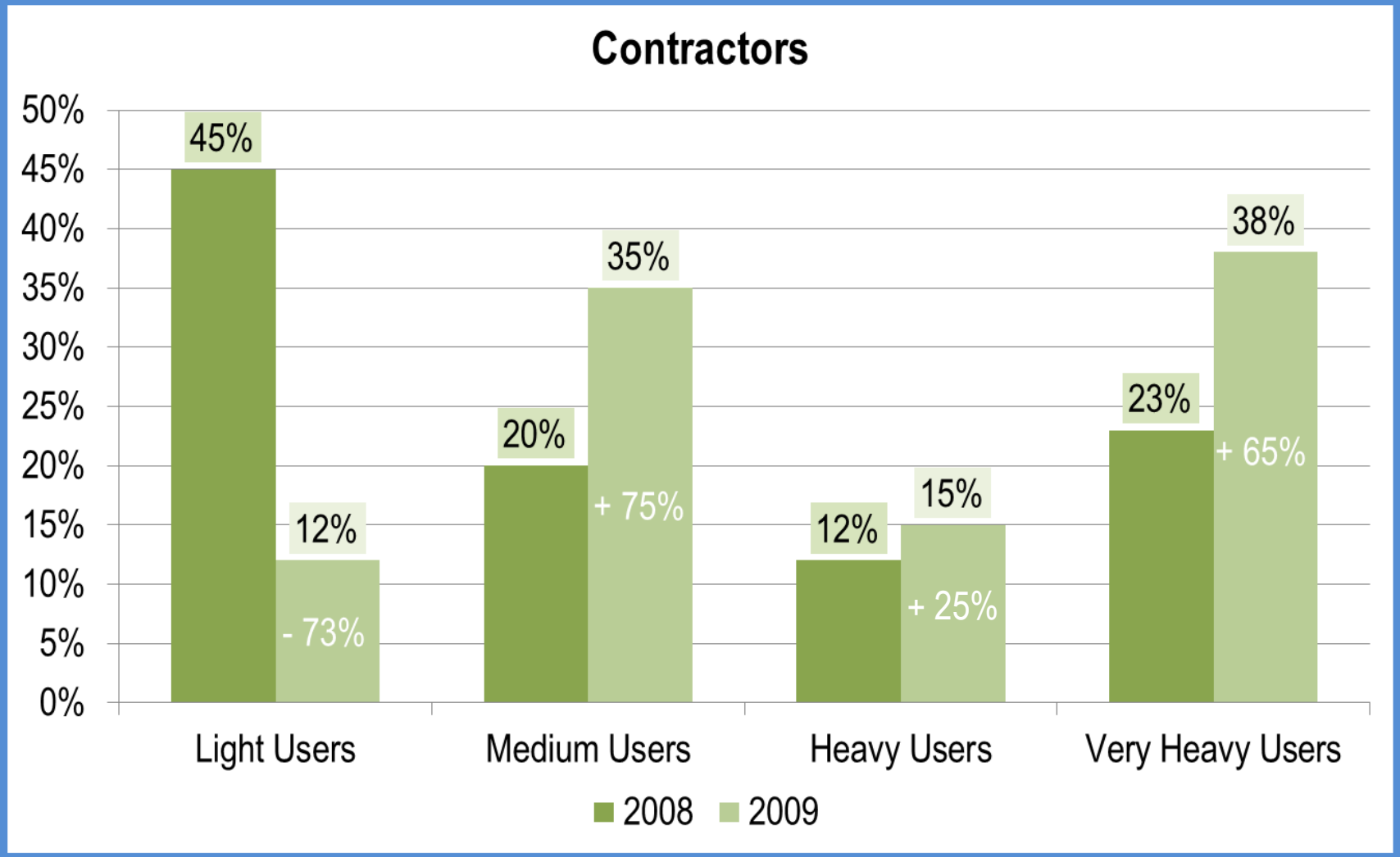

Building Information Modeling (BIM) in the Construction Phase

Office of the State Architect

Widely Acknowledged Problems

- 30% of projects do not make schedule or budget

  - Construction Management Association of America (CMAA) Industry Report 2007

  - Building owners, particularly those represented by CURT, regularly experience project schedule and cost overruns.

    - Construction Users Round Table (CURT) WP 1202 2004

- 37% of materials used in the construction industry become waste

  - Movement for Innovation Industry Reports - Economist Magazine 2002

What Contractors Say

- The majority of cost and schedule overruns are due to lack of building systems coordination
- BIM, properly applied, can address these issues:
  - Need accurate 3D model of structure and architecture
  - MEP subcontractors must develop detailed 3D models
  - Subcontractors must fabricate and install from those models

Project Example: Sherman Hospital, Elgin, Illinois

- 645,000 S.F. New Campus (255 beds)
- 6 Story Patient Tower
- 2 Story Diagnostic &Treatment Center
- Cancer Center
- Emergency Department
- 2D Design Contract Documents for Construction

BIM-Based MEP Coordination

- Building modeled by OSA Consultant KFA based on contract drawings and 2D CAD files
  - Architectural
  - Structural
- Subcontractors modeled individual systems
  - HVAC duct
  - HVAC pipe
  - Plumbing
  - Electrical
  - Fire Protection
  - Pneumatic Tube
- KFA integrated individual models in Navisworks for coordination

BIM Results

- Corrected upwards of 300 critical conflicts in model
- 25% MEP construction schedule reduction
- ZERO internal coordination change orders
- No work stoppages (550 workers) due to coordination issues
- Increased off-site fabrication
- Improved quality
- Improved safety

The Construction Industry Institute (CII) has identified

BIM / VDC Related Opportunities for Increasing Contractor Productivity:

- The linking of BIM / VDC models to intelligent databases helps improve communications, reduces errors and omissions, and reduces project team and construction costs
  - The typical building project involves thousands of documents – contracts, budgets, schedules, codes, plans, specifications, cut sheets, shop drawings, fabrication details, warranty information, maintenance data, asset management information, operations procedures, etc.
  - Includes lots of redundancy and leads to unintentional sharing of inaccurate or out of date information
  - Having a common set of real-time information accessible to project owners, project managers, contractors, subcontractors, designers, consultants, and others saves times, improves communication, and reduces errors caused by conflicting information in individual documents or silo applications
    - This provides an indirect benefit to contractors when they can more consistently count on construction documents with fewer errors and/or coordination problems

- Use of BIM can also assist the contractor in better managing its workforce and materials
  - Real time project information at the job site can expedite and improve on-site decision making and work sequencing and foster collaborative problem solving and solutions
  - Virtual building models assist contractors and subcontractors to better understand the project scope and costs, and resolving conflicts, etc. before they begin construction
  - Contractors can better sequence their labor activities to eliminate down time and coordinate different trade's schedules and work areas so that construction is progressing efficiently and as fast as responsibly possible
  - Trades can better pre-package the materials needed for each day's work so there is less walking around and more work going on
  - BIM can support improved Supply Chain Management to significantly cut waste related to time, materials and labor and more efficient procurement of materials and supplies (also potentially reducing on-site storage requirements)
  - It can also assist contractors in identifying the best location for materials, supplies and equipment on an on-going basis

- 3D modeling supports prefabrications, reassembly, modularization and off-site fabrication –
  - All involving the assembly or fabrication of building systems and/or components at off-site locations in more controlled environmental conditions with
    - Better supervision,
    - Easier access to tools and
    - Less materials waste

    Which allows for
    - Improved quality and precision in fabrication,
    - Lower project costs,
    - More efficient use of labor and materials

- Fewer job-site environmental impacts
  - because of reductions in material waste, air and water pollution, dust and noise, and overall energy costs (but may also entail higher transportation costs and energy costs at off-site locations)
- Compressed project schedules – as a result of changing the sequencing of the construction work flow
  - (e.g. allowing for the assembly of components off-site while permits are being processed, concrete is being poured, etc.)
- Increased worker safety
  - through reduced exposures to inclement weather, temperature extremes, and ongoing or hazardous operations;
  - better working conditions (e.g. components traditionally constructed on-site at heights or in confined spaces can be fabricated off-site and then hoisted into place.

- Changes in materials can reduce the weight of construction components, which in turn make them easier to handle, move and install
  - Labor productivity for the same activity increased by 30% where lighter materials were used
  - Labor productivity also goes up when materials are easier to install and/or were pre-fabricated
  - Less walking around getting answers, materials, and tools leads to more physical work getting done
- Additionally, having Contractor “as-built” information provides more “value added” services and data for Owners operating and maintaining their own buildings

Public Sector Use of BIM

The following list has been compiled by the OSA as of October 2012. It is intended to provide an insight into other public entities with BIM requirements/standards, not to be an all inclusive list.

Federal Agencies:

- General Services Administration
- Air Force
- Army Corp of Engineers
- Coast Guard
- Navy
- Veterans Affairs

State Agencies:

- Dormitory Authority of the State of New York
- Georgia State Financing and Investment Commission
- State of Ohio State Architect's Office
- State of Texas Facilities Commission
- State of Wisconsin Department of Administration
- State of Massachusetts Division of Asset Management, Office of Planning, Design and Construction

State Colleges and Universities:

- Los Angeles Community College District
- Georgia Tech University Facilities Management Office
- Indiana University Architect's Office

Municipalities:

- New York City Department of Design + Construction
- New York City School Construction Authority

Summary

State of Tennessee will benefit from a holistic and proactive approach of design, construction, operations, maintenance and facilities management

- through the utilization of industry best practices and technology regarding
  - Taking a life cycle approach to realizing our building projects
  - Taking a highly collaborative approach to addressing our building project needs
  - Utilizing the best design and construction delivery method for each project
  - Improving the productivity of the design and skilled labor construction work force
  - Increasing our emphasis on high performance building solutions
  - Utilizing Building Information Modeling and sharing associated information amongst design, construction, fabrication, and operations team members
  - Increasing the use of off-site prefabrication
- which will result in higher performing project teams and building projects
- which are more efficient and effective and have a lower the Total Cost of Ownership

Questions and Answers

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